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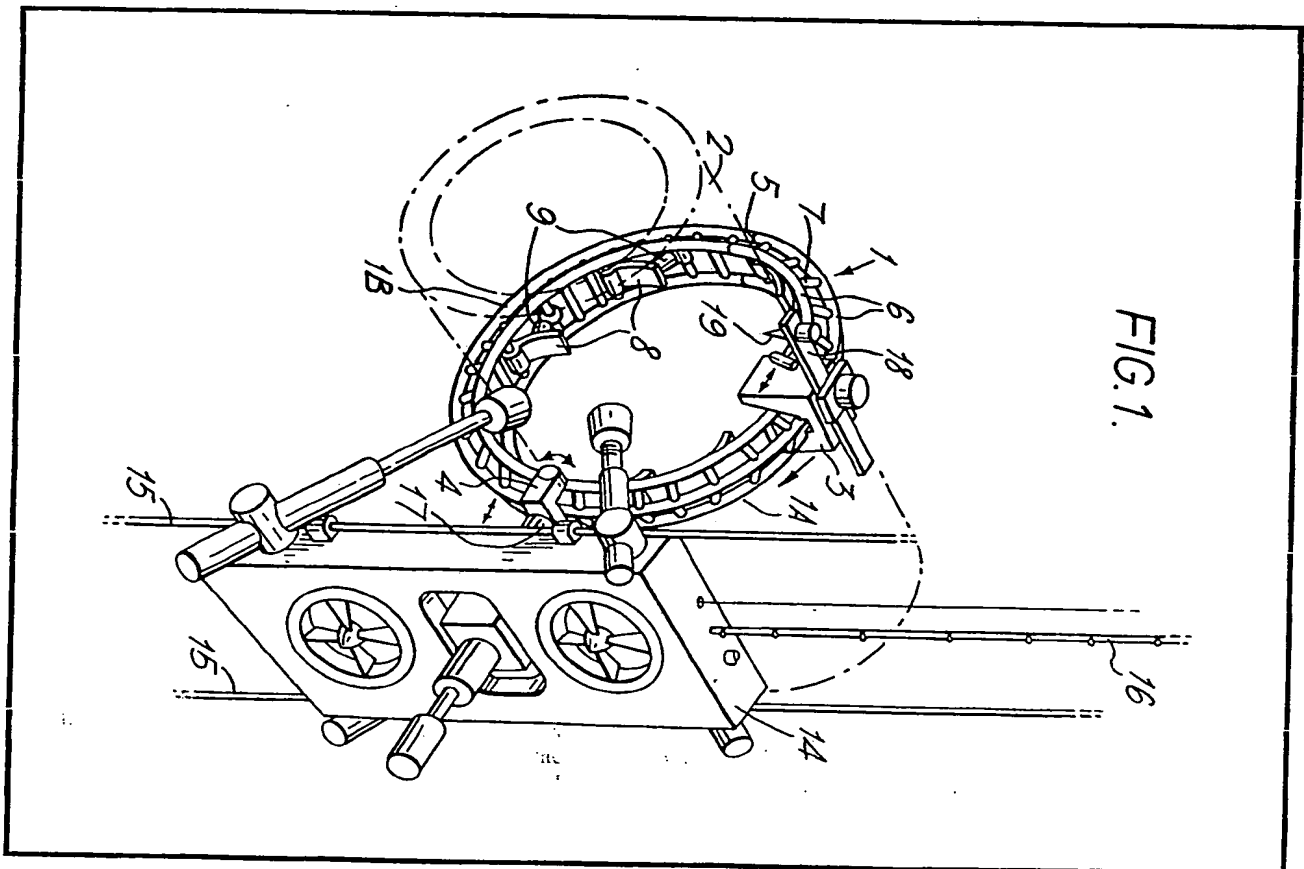
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(54) Apparatus for attachment to  
tubular or elongate structural  
members

(57) An apparatus for attachment to tubular or elongate structural members, notably for use in the cleaning, inspection, repair etc of the supporting structures of offshore oil or gas platforms. The apparatus comprises a track unit 1 adapted to embrace the structural member 2, this unit being articulated at one circumferential position 4 and separable at another such position 5 to enable it to be embraced about the structural member from a position laterally spaced therefrom. A carriage 3 is arranged to traverse circumferentially around the closed track, carrying such cleaning, in-

spection, repair or the like equipment 19 as is required.

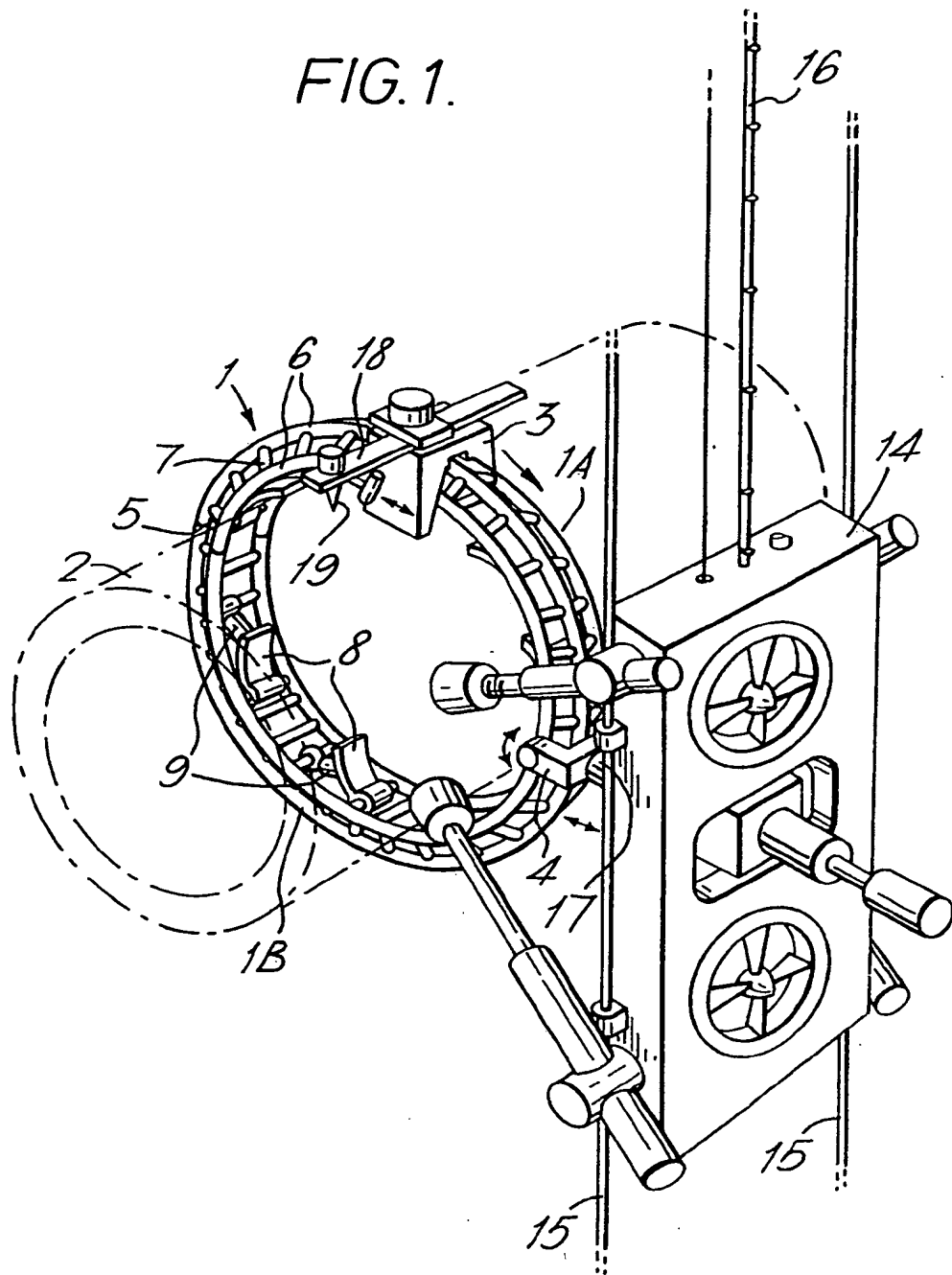


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FIG. 1.



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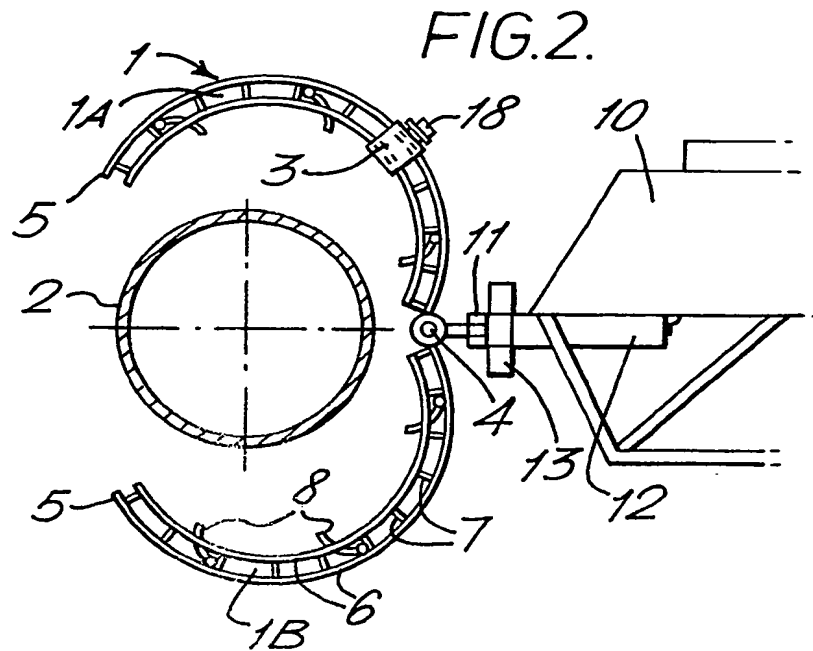


FIG.3A.

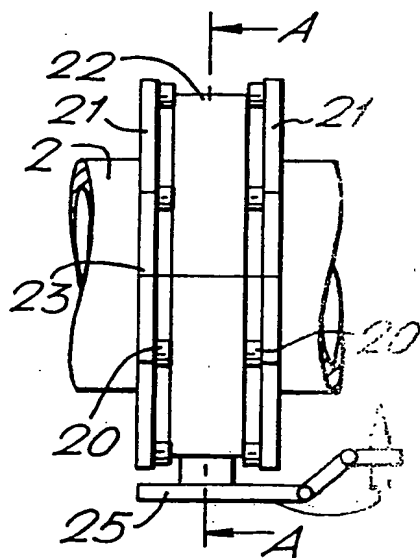
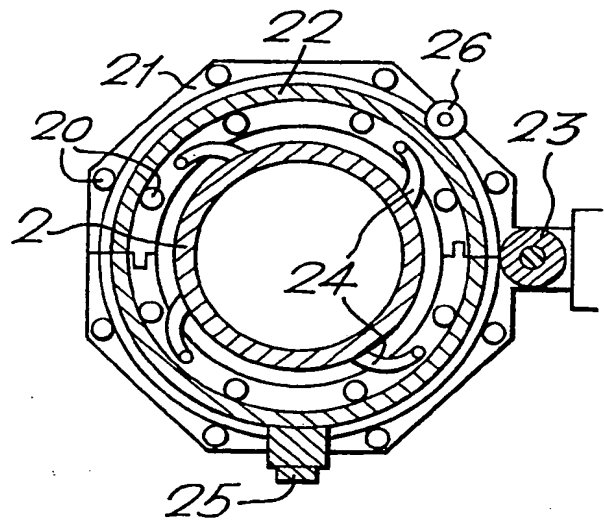


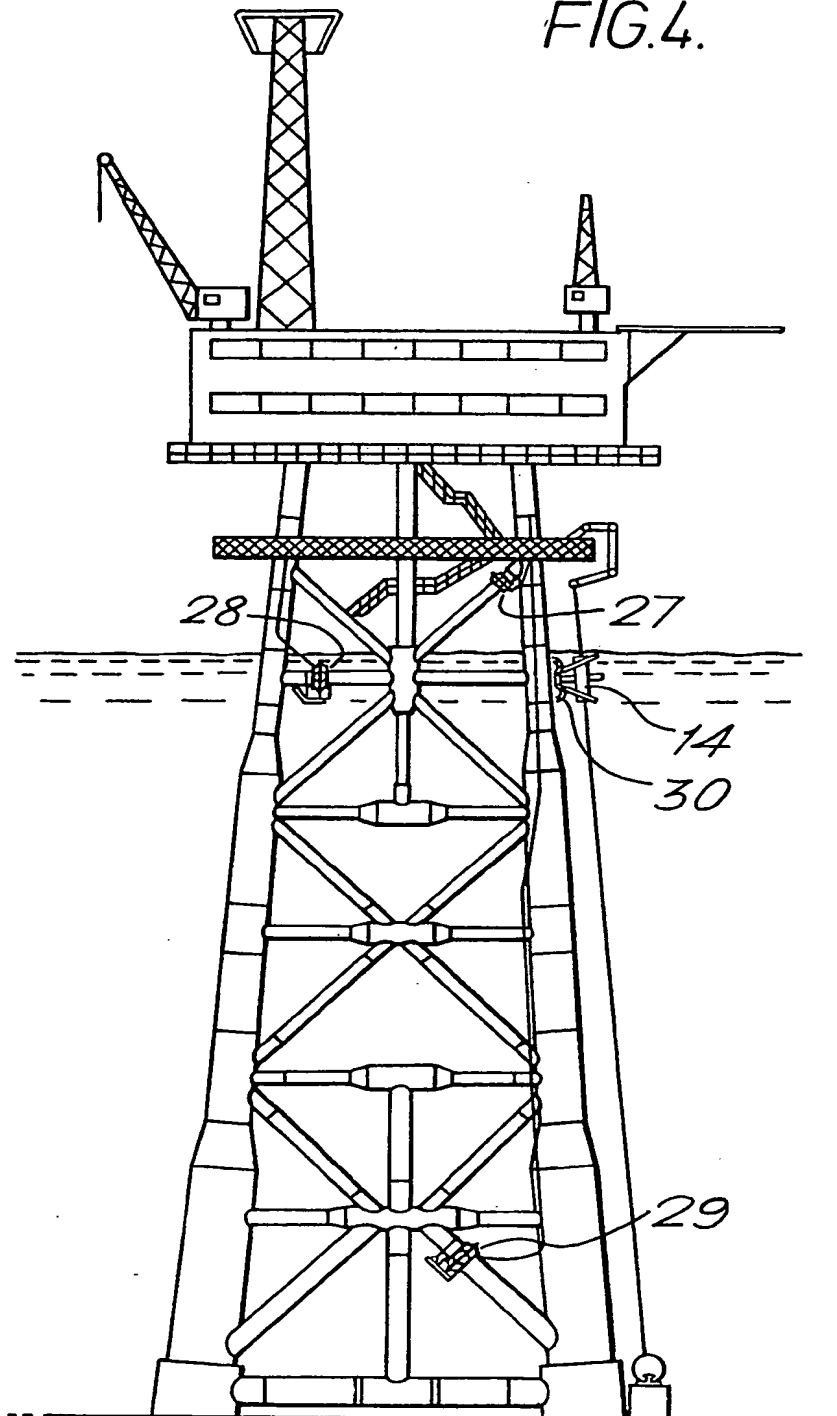
FIG.3B.



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FIG.4.



## SPECIFICATION

### Apparatus for attachment to tubular or elongate structural members

5 The present invention relates to apparatus for attachment to tubular or elongate structural members, notably for use in performing automatic cleaning, inspection, repair or the like operations circumferentially around such members. The invention is especially concerned with structures of which significant proportions are disposed under water—such as the supporting structures of offshore oil and gas platforms.

10 Apparatus in accordance with the invention is particularly suited for use in the cleaning, inspection and repair of offshore oil and gas platform structures manufactured from tubular steel sections. It is known that failure in such a structure is most likely to occur at the welded nodal points between adjacent sections, the highest corrosion effects being at the splash line due to the high oxygen content of the spray to which the structure is exposed. The welds normally extend around the entire circumference of the tubular sections and need to be cleaned before inspection and repair can be carried out. Often, however, a crack in the welding is such that an immediate repair is not necessary. Also marine growth upon the structure can be a slow process. In such cases the change or trend in the condition of the structure requires to be measured over a period of time, and from a fixed datum line or point on the structure.

At present, cleaning inspection and repair work on the submerged structures of offshore oil and gas platforms is usually performed by teams of divers with manually operated equipment. This is, at best, a relatively hazardous and inefficient pursuit. The divers are often limited to operating at ebb tides and in calm weather, and even so may be subject to dangerous water currents in the vicinity of the structure. The depth of operations can also be a limiting factor for divers.

In view of the foregoing, the present invention seeks in particular to provide an apparatus to enable the automatic traversal of cleaning, inspection, repair or like equipment circumferentially around a tubular or elongate element of such a structure which can be readily attached to the structure from a position laterally spaced therefrom; and which can remain operative in position on the structure for a protracted period of time if so required, before eventual recovery.

The invention resides in apparatus for attachment to a tubular or elongate structural member comprising means to define a closed track adapted to embrace the structural member, which means are articulated at at least one circumferential position and separable at another such position to enable the track to

be embraced about the structural member from a position laterally spaced therefrom; and a carriage adapted to traverse circumferentially around the closed track.

70 In use, the track-defining means (hereinafter, for convenience, referred to as a 'track unit') can be held in position on the structural member, e.g. a tubular steel section of an offshore oil or gas platform, by the clamping action which is obtained by closing the unit about its point(s) of articulation from the 'open' condition in which it is offered to the structural member. In a preferred form the track unit comprises a pair of rigid semi-circumferential elements hinged together at one circumferential end and lockable together at their other circumferential ends. When attachment to the structural member by a clamping action is employed the contact between the track unit and structural member when the track unit is in place may be made by means of adjustable centering pads or the like which extend radially inwards from the track unit. The centering pads can be used to ensure coaxial alignment of the track and structural member and also to enable the same track unit to be attached to different structural members having a range of cross-sectional dimensions. Although attachment of the track unit to the structural member by such a clamping action is generally to be preferred, it is nevertheless possible for the attachment to be made e.g. by means of bolts or other fixtures if so desired.

100 The track itself may be defined by a circumferentially continuous stationary structure comprising rails or some other form of guideway, with the carriage being motorised and adapted to engage with and be driven around the guideway. Alternatively the track may be defined by one or more annular arrays of rollers or other anti-friction members, with the carriage comprising a ring borne by such members and arranged to be driven in rotation.

110 The carriage may carry various pieces of equipment for performing cleaning, inspection, repair or like operations on the structural member, and preferably includes a manipulator allowing for repositioning and reorientation of the working equipment relative to the carriage.

The types of structural members upon which apparatus according to the invention will operate will generally be of circular cross section although track units and associated carriages may be designed for use with structural members of other cross sections if so required.

125 When using apparatus according to the invention for work on the submerged portions of structures such as offshore oil and gas platforms, the track units may be attached to appropriate structural members by divers or by means of a suitable mechanism on a

manned or unmanned submersible. It is advantageous, however, to use the apparatus of the present invention in conjunction with the positioning apparatus disclosed in our copending United Kingdom patent application No (Agents ref 7842) whereby cleaning, inspection, repair or like equipment can be positioned at selected locations on a suitable structure, attached to the structure, perform the required operation(s) and subsequently be recovered from the structure, all by remote control.

The invention will now be more particularly described, by way of example, with reference to the accompanying schematic drawings, in which:

*Figure 1* is an isometric view of one embodiment of apparatus according to the invention in place upon a tubular structural member;

*Figure 2* shows a similar embodiment to that of *Fig. 1* in course of attachment to a tubular structural member;

*Figure 3A* is a side elevation of a second embodiment of apparatus according to the invention in place upon a tubular structural member;

*Figure 3B* is a cross section on the line A-A of *Fig. 3A*, and

*Figure 4* shows the typical application of apparatus according to the invention on the structure of an offshore oil or gas platform.

Referring to *Fig. 1*, the illustrated apparatus comprises a track unit 1 which is shown clamped in position around a section 2 of the submerged tubular steel structure of an offshore oil or gas platform, and a carriage 3 which can traverse circumferentially around the track provided by unit 1. The track unit is made in two semi-circular halves 1A and 1B hinged together at 4 so that the unit can be opened when it is to be attached to/recovered from the structure, and which, when the unit is in its closed position, are locked together by a suitable mechanism at their abutting free ends 5. In the illustrated embodiment each half of the track unit comprises three semicircular tubes 6 held in a triangular array by cross struts 7 and which, when the track unit is closed, collectively define three continuous rings. There are, however, many other suitable forms of construction for the track unit which will occur to those skilled in the art.

Pivoted to the track unit, and extending radially inwardly therefrom, are six centering pads 8. It is these pads rather than the rings 6 which make contact with the member 2 when the track unit is in its operative position, and they enable the central axis of the track unit to be accurately aligned with that of its supporting member 2. In addition the pads 8 enable the same track unit to be attached to structural members of different diameters within a certain range. The inclination of the pads inwardly from the track unit may be adjusted e.g. by means of electrical or hydraulic actuators 9.

lic actuators 9.

*Fig. 2* shows the track unit in the course of attachment to the member 2. In this case the unit is carried by a submersible 10 provided with a docking mechanism 11 by which the unit 1 can be picked up and released, and opened and closed about its hinge 4. The docking mechanism is carried by an extendable and retractable arm controlled by an hydraulic ram 12, and can be rotated through 360° by means of a rotary mechanism 13 to facilitate the positioning of the track unit on any structural member inclined between the horizontal and vertical. The procedure adopted in attaching the track unit to the member 2 is to advance the unit, in its open condition illustrated in *Fig. 2*, towards the member until the member lies between the two semi-circular halves 1A and 1B, whereupon the two halves are hinged together about the connection 4 until their free ends 5 lock together with the member 2 clamped between them. Thereafter the unit can be detached from the docking mechanism 11 and left in position until such time as it is to be recovered.

In *Fig. 1* the track unit unit is shown having been positioned on the member 2 by an apparatus which is more fully described in our copending United Kingdom patent application No (Agents ref 7842) but which briefly comprises a vehicle 14 guided by a pair of wires 15 strung between the deck of the platform and a clump block located on the seabed. The vehicle can be raised and lowered by a cable 16 and the guide wires 15 can be traversed horizontally, so that the vehicle can be controlled from the deck of the platform to position the track unit at selected locations on the supporting structure. The unit is carried at the end of an extendible and retractable arm 17 provided with a docking mechanism capable of performing the same functions as the mechanism 11 described above.

When the track unit 1 is in position on the member 2, the carriage 3 can be traversed circumferentially about the member, for example to track a welded node with cleaning, inspection or repair equipment carried by the carriage. The motive power for traversing the carriage may be provided e.g. by an electric, hydraulic or compressed gas motor and the drive between the carriage and track unit 1 may be effected e.g. by means of a rotating pinion on the carriage meshing with a toothed rack on the track unit, or by means of a chain or friction drive. The carriage shown in *Fig. 1* is provided with a simple form of manipulator 18, carrying e.g. a sonic crack detector 19, and which can extend and rotate relative to the carriage. It will be appreciated, however, that more complex forms of manipulator may be provided to afford considerable repositioning and reorientation of various pieces of equipment carried by the carriage, if so desired.

Turning now to Fig. 3, this shows another embodiment of a track unit/carriage assembly according to the invention, in which the track is constituted by two annular arrays of rollers 20 borne by a pair of cheek plates 21, and the carriage is in the form of a ring 22 borne for rotation by the rollers 20. The track unit comprising plates 21 and rollers 20 is constructed in two circumferential halves hinged together at 23, and the carriage ring 22 is likewise split and hinged so that when the hinges and splits of the track unit and carriage ring are lined up the whole assembly can be opened and attached to a structural member 2 in the same fashion as the track unit 1 previously described.

The track unit is provided with centering pads 24 serving the same purpose as the pads 8 of the previously described embodiment, and the carriage ring 22 has a mounting point for a manipulator 25 and such cleaning, inspection, repair or the like equipment as may be required. With the assembly in position on a structural member 2, the carriage ring can be rotated by means of a drive pinion 26, operated by a servo motor (not shown) attached to one of the cheek plates 21, and which meshes with a complementary tooth form provided on the carriage ring.

By way of example Fig. 4 shows three track unit/carriage assemblies according to the present invention fitted to a typical offshore oil or gas platform structure, assembly 27 above the splash line, assembly 28 in the splash line and assembly 29 below the splash line. A further assembly 30 is shown attached to the vehicle 14 of a positioning apparatus of the type described in our copending United Kingdom patent application No (Agents ref 7842) and in its open condition ready to be fitted to the platform structure. In use, power supplies and control signals can be fed from the deck of the platform to the units attached to the platform structure by trailing cables, and likewise for any signals to be relayed back to the deck e.g. from monitoring equipment carried by the units. Alternatively, the need to employ such cables can be avoided if the units have their own internal power supplies and communications are effected e.g. by means of radio for any equipment attached to the structure above the water line or by ultrasonic transmission for submerged equipment.

#### CLAIMS

1. Apparatus for attachment to a tubular or elongate structural member comprising means to define a closed track adapted to embrace the structural member, which means are articulated at at least one circumferential position and separable at another such position to enable the track to be embraced about the structural member from a position laterally spaced therefrom; and a carriage adapted to

traverse circumferentially around the closed track.

2. Apparatus according to claim 1 wherein said means comprise a pair of rigid semi-circumferential elements hinged together at one circumferential end and lockable together at their circumferential ends.

3. Apparatus according to claim 1 or claim 2 wherein the track is defined by a circumferentially continuous stationary guideway and the carriage is motorised and adapted to engage with and be driven around such guideway.

4. Apparatus according to claim 1 or claim 2 wherein the track is defined by one or more annular arrays of anti-friction members and the carriage comprises a ring borne by such members and arranged to be driven in rotation.

5. Apparatus according to any preceding claim wherein said means include a plurality of elements extending radially inwardly therefrom to an adjustable degree whereby the apparatus can be attached by a clamping action to different structural members having a range of cross-section dimensions.

6. Apparatus for attachment to a tubular or elongate structural member substantially as hereinbefore described with reference to Figs. 1 and 2 or Fig. 3 of the accompanying drawings.

7. The combination of a tubular or elongate structural member and apparatus attached thereto in accordance with any preceding claim.

8. A combination according to claim 7 wherein said structural member is disposed under water.

9. A combination according to claim 8 wherein said structural member comprises part of the supporting structure of an offshore oil or gas platform.

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